Sea ice and open water spectral albedo shape derived from ARISE data

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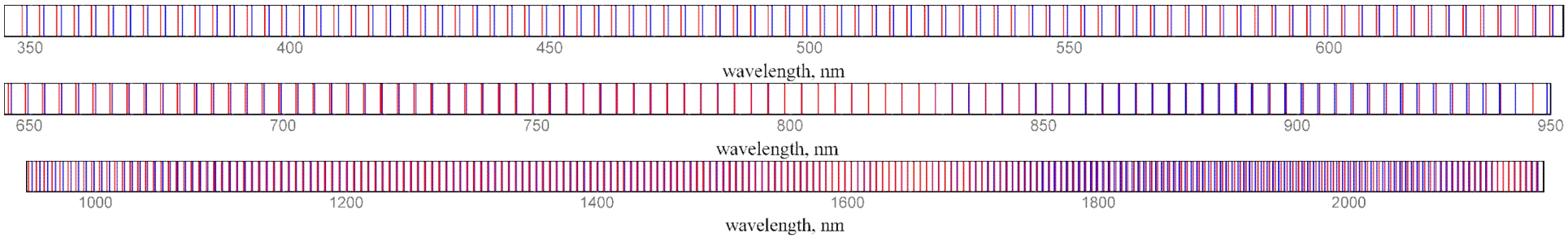
Data from ARISE, I

Solar Spectral Flux Radiometer (SSFR)

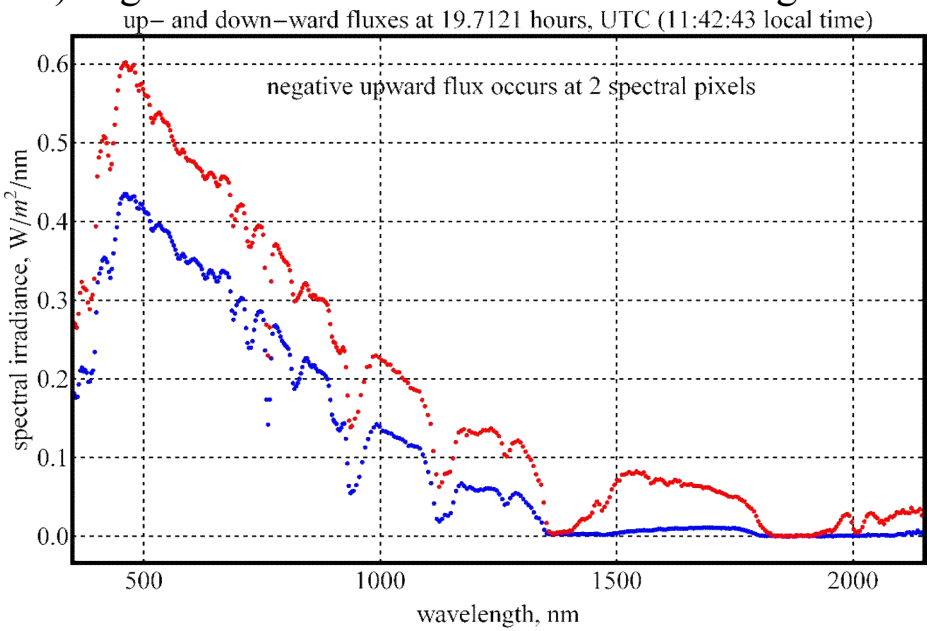
The SSFR is a moderate resolution irradiance spectrometer, simultaneous zenith and nadir viewing.
Spectral range: 350 nm through 2150 nm (covers ~95% of the incoming solar incident irradiance spectrum).
Each SSFR consists of 2 light collectors connected to 2 identical pairs of spectrometers through fiber optics.

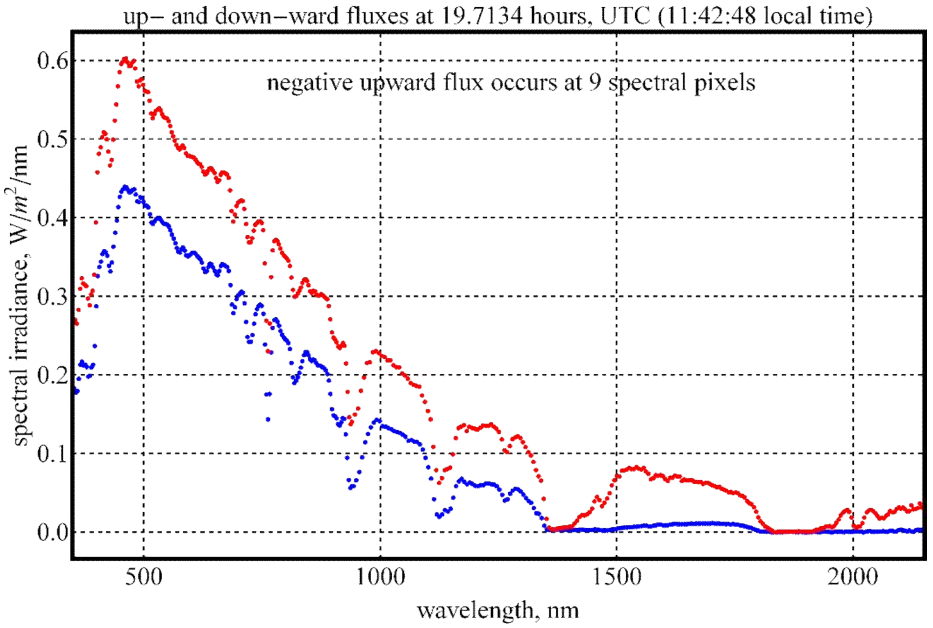
Data issues:

1) the sets of nadir and zenith wavelength are not the same: there are 414 nadir and 413 zenith wavelengths;

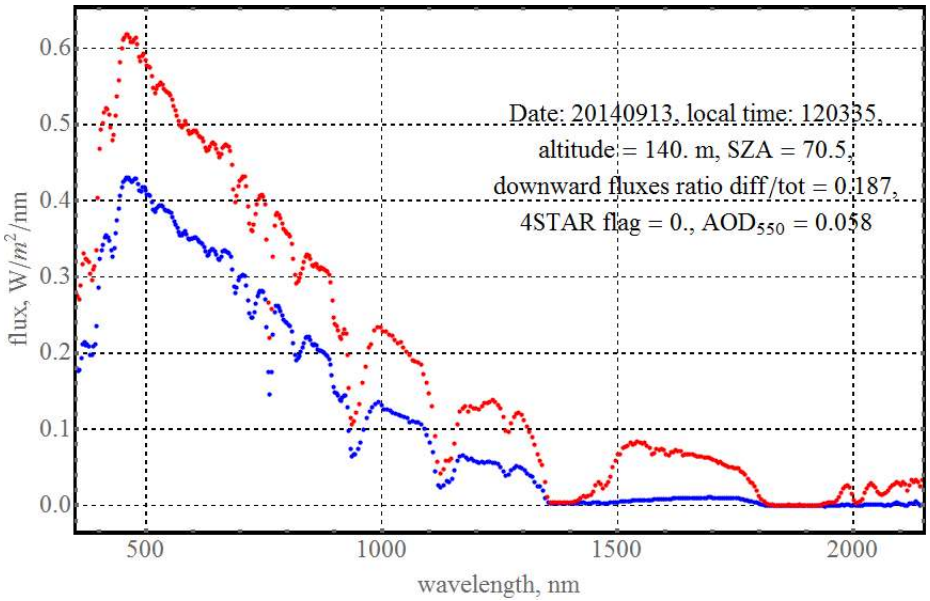


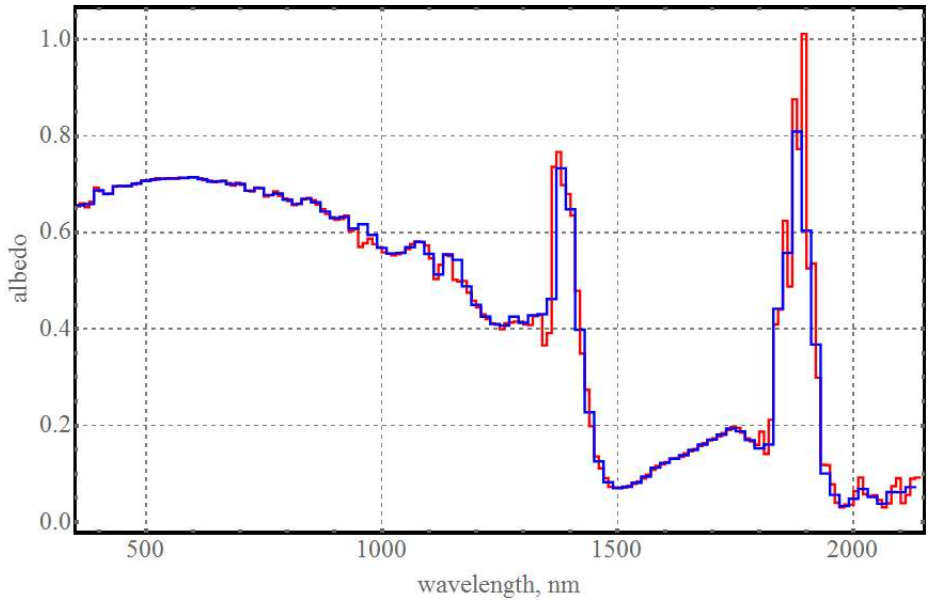
2) negative flux values at different wavelengths.





Data from ARISE, II





"Hidden" SSFR data problem:
Noisy irradiance data, meaningless albedo in certain spectral ranges

Down-ward and up-ward fluxes with SSFR full spectral resolution

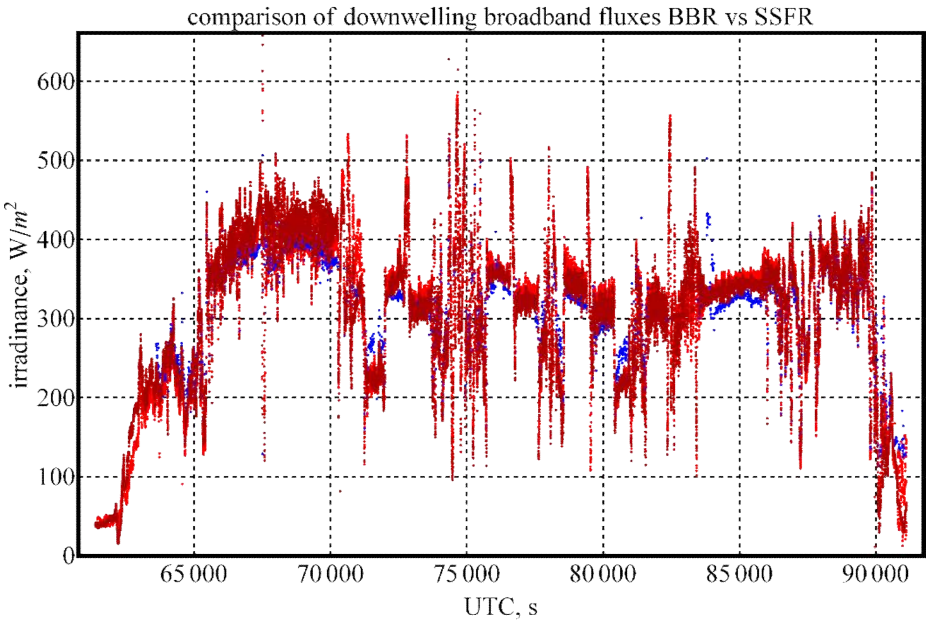
Spectral albedo with integration intervals of 10 nm and 20 nm.

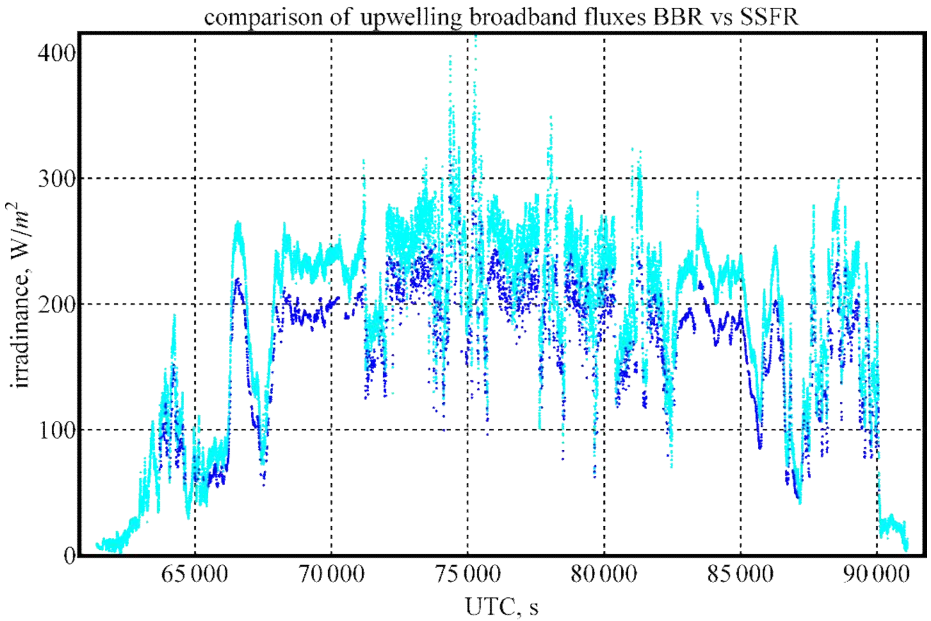
Data from ARISE, III

BroadBand Radiometers (BBR)

Solar and IR BBR are modified Kipp & Zonen CM-22 pyranometers (200 - 3600 nm) and CG-4 pyrgeometers (4.5 - 42 mm), respectively, and a Dynamax SPN1 Total/Diffuse Solar Radiometer (200 - 3600 nm). SPN1 data are used to detect overhead clear sky condition. Solar up- and down-welling fluxes from the BBR can be compared with total (spectrally integrated) fluxes from SSFR for consistency check.

data consistency: SSFR integrated broadband flux vs. BBR

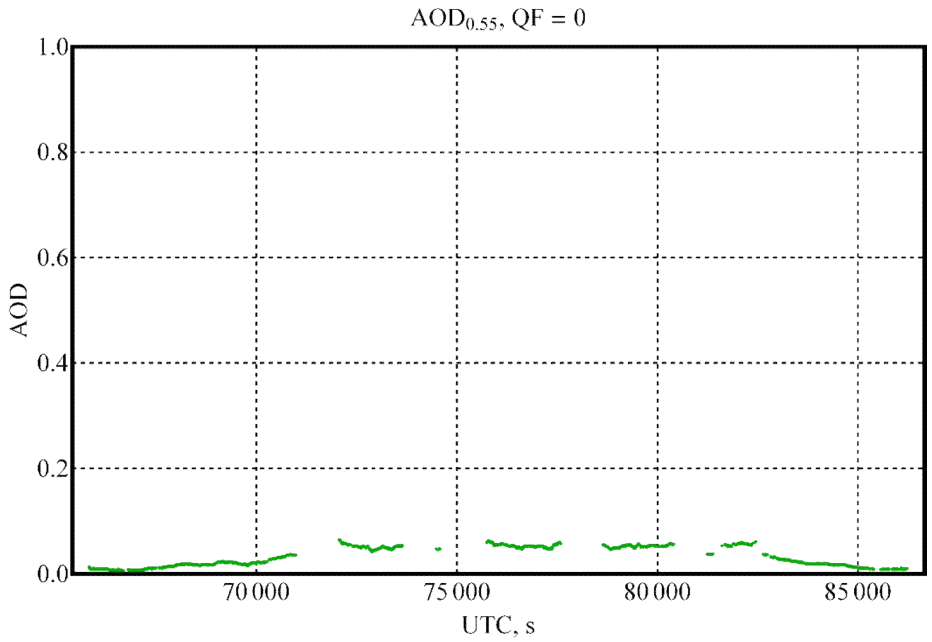


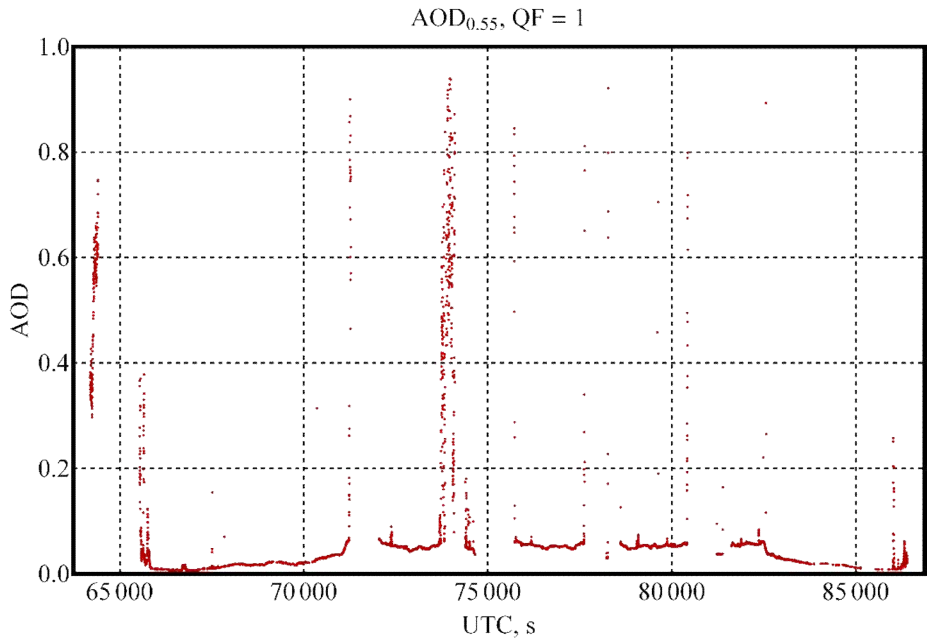


Data from ARISE, IV

Spectrometer for Sky-Scanning, Sun-Tracking Atmospheric Research (4STAR)

4STAR allows direct-beam measurements of aerosol optical depth (AOD), water vapor, ozone, and NO_2. 4STAR measures AOD in 17 spectral bands. AOD data have quality flag (QF) of 0, 1, and fill value. AOD data with QF = 0 are likely an indication to clear sky above the aircraft, while data with QF = 1, should be considered with caution – AOD could be too high, which may indicate presence of clouds. Non-fill-value QFs do not guarantee that retrieved AOD is meaningful: both QFs of 0 and 1 have fill value AOD.





Sea ice scene recognition I

Automated aerial image analysis

Problem: tens of thousands of images during the campaign

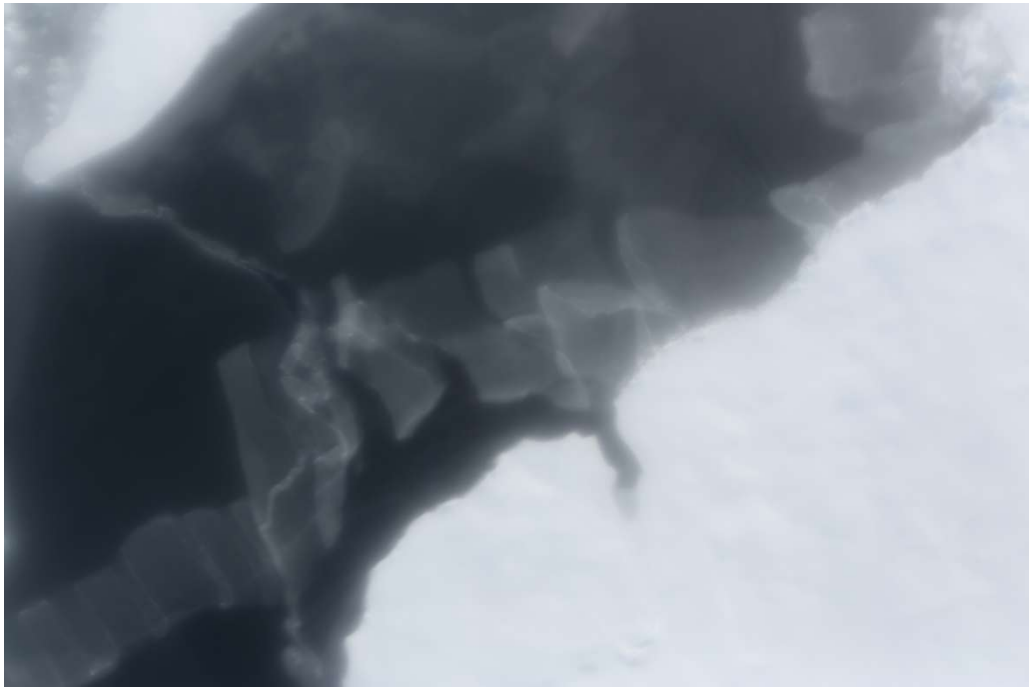
RGB channels of images taken during flights were analyzed for minimum, maximum, and mean values and for standard deviation. Small standard deviation indicates more uniform scene. Small maximum value indicated open water. Great minimum value indicates snow/ice.

date: 2014/09/13, local time: 11:28:52

	Max	Min	Mean	STD
Red	229	87	174.3	13.7
Green	231	104	182.4	12.5
Blue	235	129	193.2	10.7

date: 2014/09/13, local time: 12:03:35

	Max	Min	Mean	STD
Red	232	193	215.9	4.4
Green	235	201	222.5	3.9
Blue	243	208	231.3	3.7



Sea ice scene recognition II

$$NDSIa = \frac{a_{550} - a_{1550}}{a_{550} + a_{1550}} \qquad NDVIa = \frac{a_{865} - a_{550}}{a_{865} + a_{550}}$$

$$a_{\lambda_0} = \int_{\lambda_0-\delta\lambda}^{\lambda_0+\delta\lambda} F_{\uparrow}(\lambda)d\lambda \Big/ \int_{\lambda_0-\delta\lambda}^{\lambda_0+\delta\lambda} F_{\downarrow}(\lambda)d\lambda, \quad \delta\lambda = 25nm$$

$NDSIa$ = 0.888, $NDVIa$ = -0.0407,
QF = 0, AOD_{550} = 0.052,
$F_{dn,diff}/F_{dn,tot}$ = 0.170

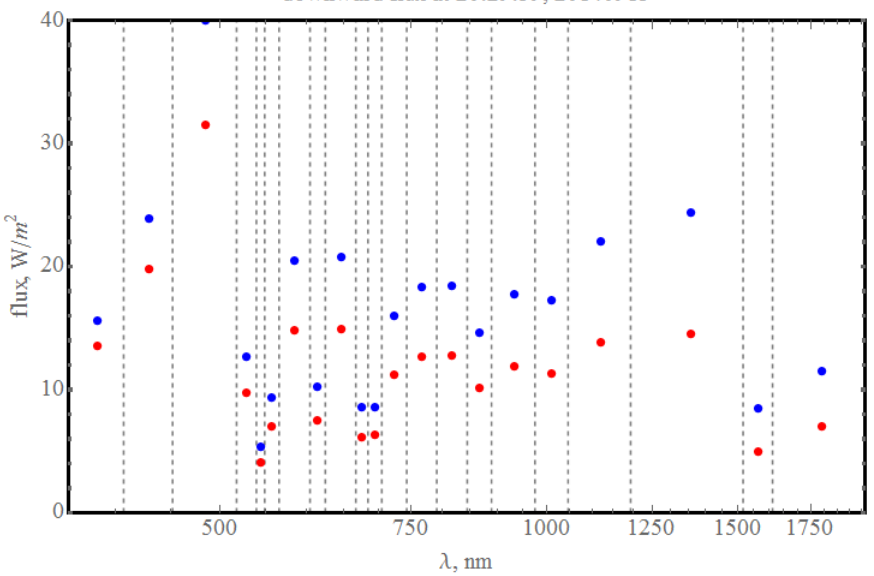
$NDSIa$ = 0.779, $NDVIa$ = -0.0402,
QF = 0, AOD_{550} = 0.058,
$F_{dn,diff}/F_{dn,tot}$ = 0.187

Unfortunately, approach **failed.**

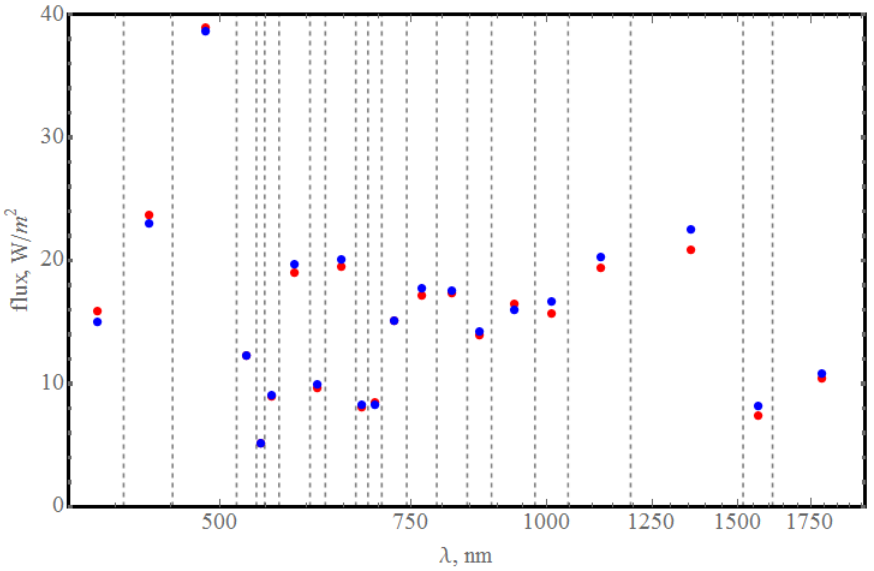
Scene selection for sea ice modeling is manual, based on aerial images, videos, and information from spectral indices and simple image processing.

Clear sky scene recognition

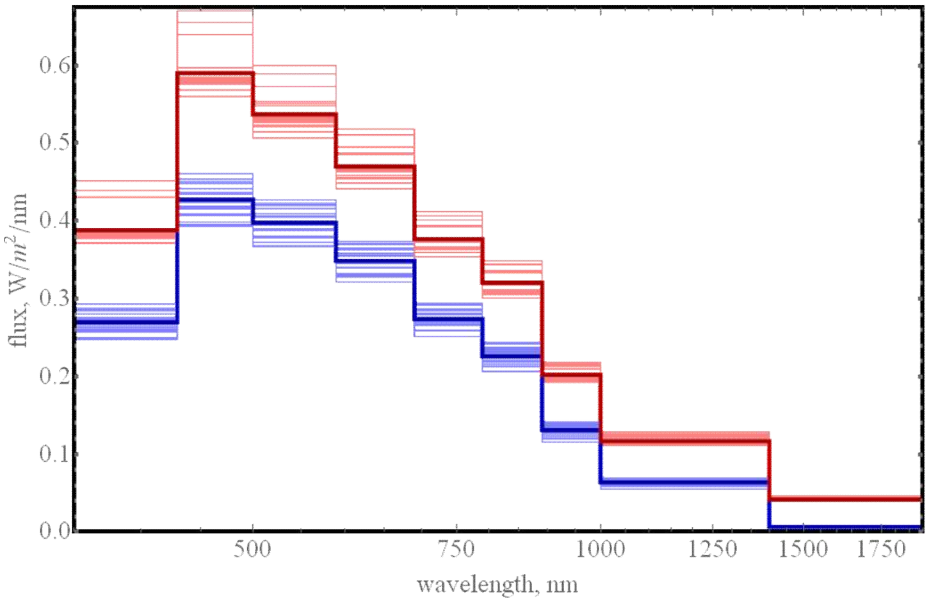
QF = 1, AOD_{550} = 0.333, $F_{dn,diff}/F_{dn,tot}$ = 0.428

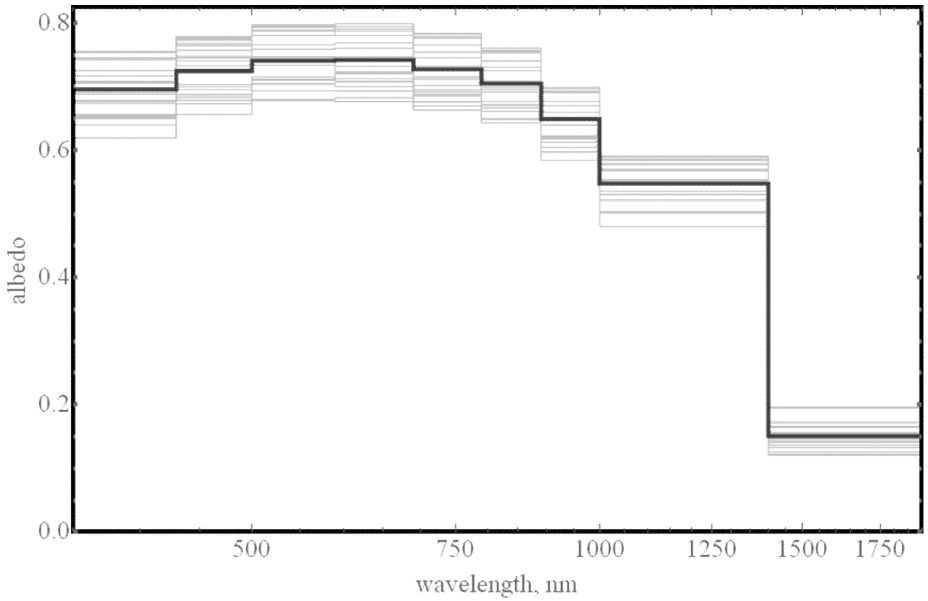


QF = 0, AOD_{550} = 0.058, $F_{dn,diff}/F_{dn,tot}$ = 0.187

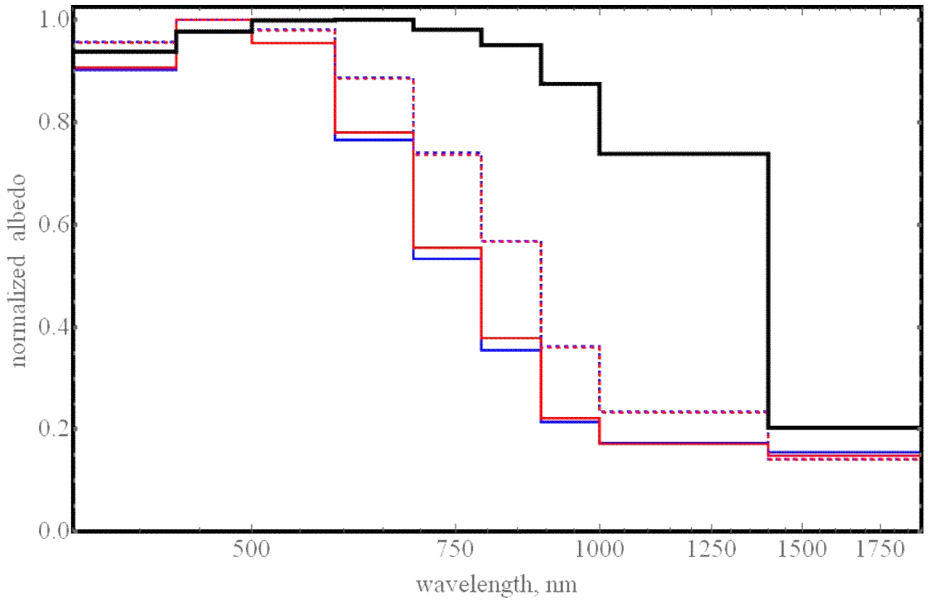


Spectral albedo of sea ice and its profile





Spectral fluxes acquired over sea ice and integrated:
red lines – downward flux, blue lines – upward flux,
thick lines – average fluxes.



Spectral albedo profiles of sea ice:
black – SSFR integrated over Fu – Liou spectral bands;
Fu – Liou code albedo LUT:
red lines – "warm" ice, blue lines – "cold" ice,
solid lines – new ice, dashed lines – old ice.

Conclusions and future work

1. Air born campaign ARISE provided a lot of useful information on radiative properties of the surface;
2. Software for correct processing of the data (cleaning, spectral integration, image processing) was developed;
3. Approaches for scene classification was developed but manual selection from “pre-screened candidates” is needed;
4. Clear sky ice covered scenes were selected, spectral albedo profile was derived from those scenes;
5. Comparison of the derived profile with that encoded in Langley FU-Liou code revealed significant difference;
6. Open water recognition has to be done, suspended upon flight video from experimentalists is available;
7. Collaboration with the experimental groups is ongoing to ensure better data quality from future missions.

Thank you!